DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2009/71

Nordmine Archives: Part 1. Digital geological and geochemical data from Nordisk Mineselskab A/S' mineral exploration in central East Greenland 1968–83

Bjørn Thomassen & Tapani Tukiainen

(1 CD-Rom included)

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF CLIMATE AND ENERGY

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Enclosed DVD

- Report text
- NM Coding Manual 1981
- Folder no. 1. Original NM ASCII files
- Folder no. 2. Original transformed NM EXCEL files
- Folder no. 3. Final master NM EXCEL files
- Folder no. 4. Original transformed NM SHAPE files
- Folder no. 5. Final master NM SHAPE files
- Folder no. 6. NM PDF sample maps

1. Abstract

After the Blyklippen lead-zinc deposit at Mestersvig was mined between 1956 and 1962, Nordisk Mineselskab A/S (Nordmine) explored for new deposits in East Greenland between 70° and 74°30'N lat. In the period 1968–83, a large number of samples were collected, described and analysed. These data were stored in the Nordmine Database, a digital database in Fortran programming language with geocoded geological and geochemical information. Database attributes were described in a Coding Manual that is enclosed with this report. The base contains data on *c.* 10,300 rock samples, *c.* 3,800 heavy mineral concentrates and *c.* 2,800 stream-sediment and soil samples. After the company's closure in 1991, the Nordmine Archives, including the samples and a copy of the database, were stored at the Geological Survey of Greenland, now GEUS.

The present report describes how the original Nordmine Database in ASCI-format has been made accessible to contemporary IT users and it offers the new files produced in six folders on a DVD. The following adoptions have been performed: Firstly, the raw data were transformed to Excel files and then converted to Shape files. Finally three maps with locations for rock samples, heavy mineral concentrates and stream-sediment and soil samples, respectively, were produced as PDF files at scale 1:250,000.

The topographic maps used with the original Nordmine Database were compiled between 1931 and 1950. When compared with a new digital topographic map produced by GEUS in 2003, deviations between the two maps of more than 1 km may occur. Thus, a transformation matrix of map data points was constructed and the original sample location coordinates were transformed to the new map base. The enclosed maps contain the modern topographic background data and the transformed sample locations with sample numbers.

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2. Introduction

Nordisk Mineselskab A/S (Northern Mining Company Ltd. or Nordmine), was established in 1952 to investigate and mine the Blyklippen lead-zinc deposit at Mestersvig, central East Greenland. As no Greenland mining law existed at that time, the company was granted the rights by a special law for mineral exploration and mining for 50 years in a *c.* 100,000 km^2 concession area in East Greenland between 70° and 74°30'N lat. Geologically, the region is dominated by the north–south-trending Caledonian fold belt and coast-parallel rift basins with Late Palaeozoic and Mesozoic sediments, as well as Palaeogene igneous rocks (Figure 1, Henriksen *et al.* 2000).

Simultaneously with mining at Blyklippen 1956–1962, summer exploration was performed in the concession area. After 1958, the work concentrated on a major molybdenum occurrence at Malmbjerg, some 25 km south of Blyklippen, and up to 1962 comprehensive investigations in various joint ventures were carried out. However, feasibility studies showed that the indicated resource of 120 million tons with 0.25% MoS_2 was not profitable given the molybdenum price of the time, and it was decided to resume the regional mineral exploration while waiting for a better molybdenum market price. Renewed exploration was carried out in the period 1968–1983 and a large number of new and diverse mineral occurrences were found and investigated. However, the company did not succeed in bringing any of these into production. In 1984, mineral exploration was abandoned and effort was concentrated in a joint venture exploring for hydrocarbons in Jameson Land to the south. This ceased in 1990 without positive results and in the following year the company was liquidated.

During the exploration, a large amount of economic-geological information was collected from this remote part of Greenland and this was documented for each year in company reports. Many of these are in German, as much of the exploration personnel came from the Technical University of Leoben, Austria. A review of the activities and results was published by Harpøth *et al*. in 1986 in which many of these reports are cited.

After the liquidation, the Nordmine geological archives containing reports, maps, rock- and sediment samples were stored at the Geological Survey of Greenland (GGU), now GEUS. The exploration reports have been made available for the public through the DODEX web facility (www.GEUS.DK/DODEX). However, large amounts of raw sample data, including chemical analyses, have not been accessible but this is rectified by the present report with the data presented on a DVD.

This report was prepared on contract to the exploration company Avannaa Resources Ltd., Copenhagen.

3. Database history

In order to be able to handle the increasing amount of exploration data, Nordmine decided in 1976 to establish a digital database with geocoded geological and geochemical information about the rock, drainage and soil samples collected in Greenland. It was a customised database containing tabular data with attribute descriptions. The database management system (DBMS) was based on a suite of storage and retrieval routines in Fortran programming language. The DBMS system was developed in cooperation with the Institute of Mathematical Statistics and Operations Research (IMSOR), Technical University of Denmark, Copenhagen.

In the years 1977 and 1978 the DBMS was developed and the 1968–76 data were uploaded. New exploration data were continuously added between 1979 and 1983. After the company's closure in 1991, a copy of the database was stored at the NEUC computer facility. When this was closed down, the database was dumped in ASCI-format on magnetic tapes which were stored at the Geological Survey in Copenhagen. In 1996 these data were transferred to a CD-ROM. In connection with the aims of the present report, these data have been compiled in 2009 to Excel spread sheets and enclosed on a DVD.

The database was used to produce various statistical parameters and diagrams, and geochemical maps in order to outline geochemical anomalies which constituted follow-up targets for the company's exploration work. Some of these data are stored as prints and maps in the Nordmine Archives, others have been published, e.g. Conradsen *et al.* (1976), Hintsteiner (1977), Hallenstein *et al.* (1981), Clausen & Harpøth (1983), Harpøth *et al.* (1986) and Thomassen (1990). Unfortunately, most database outputs were produced in the period 1983–84, i.e. after the mineral exploration had ceased.

4. Database contents

During the mineral exploration by Nordmine in the period 1968–83, a large number of samples were collected, described and analysed, the data being stored in the Nordmine Database. The data pertains to three main sample types.

- Rock samples (*c.* 10,300 geocoded samples) including various types of mineralised samples from outcrop (selected hand samples, grab samples, chip samples and drill cores), loose blocks and unmineralised samples.
- Heavy mineral concentrates from panning of stream sediments (*c.* 3,800 geocoded samples).
- Stream-sediment and soil samples representing the fine fraction of raw drainage sediments or soils (*c.* 2,800 geocoded samples).

In order to make the data on the original Nordmine Database CD-ROM accessible to contemporary IT users, the following adoptions have been performed.

Step 1: The original raw data have been preserved, see Folder no. 1.

Step 2: The raw data have been transformed to Excel files, see Folder no. 2.

Step 3: The most complete Excel files have been selected, see Folder no. 3.

Step 4: The Excel files have been converted to Shape files, see Folder no. 4.

Step 5: Shape files of the most complete Excel files are presented in Folder no. 5.

Step 6: Sample maps based on Folder no. 5 have been produced, see Folder no. 6.

4.1 Overview of the contents of the six data folders

Folder no. 1 (Original_NM_ASCII_files)

The unstructured dump of ASCII files on the original Nordmine Database CD-ROM.

Folder no. 2 (Original_transformed_NM_Excel_files)

The raw data were transformed into the following Excel files:

COLLNMD.ASC.xls: Drill data from North and South Margeries Dal, Ymer Ø.

COLLSMD.ASC.xls: Drill data from North and South Margeries Dal, Ymer Ø.

CP83SMD.ASC.xls: Drill data from North and South Margeries Dal, Ymer Ø.

DC83NMD.ASC.xls: Drill data from North and South Margeries Dal, Ymer Ø.

DC83SMD.ASC.xls: Drill data from North and South Margeries Dal, Ymer Ø.

DS83NMD.ASC.xls: Drill data from North and South Margeries Dal, Ymer Ø.

KAN_A.ASC.xls: Rock samples from Flammefjeld (68º15'N, 32º18'W) 1982. No coordinates, analyses.

KEYCODE.xls: Analytical methods and laboratories.

POINT.UTM.xls: Sample numbers + coordinates.

MAS_A.ASC.xls: Rock samples from 1967–80. No coordinates, all analyses.

MAS_A.ASC_&_old_new_XY.xls: Same as **MAS_A.ASC.xls,** with available geolocation data (both original and transformed UTM-coordinates) merged to the data set. The corresponding Shape file is *mas_a.shp.*

MAS_B.ASC.xls: Heavy mineral concentrates + stream-sediment and soil samples from 1968–80. No coordinates, all analyses.

MAS_B.ASC_&_old_new_XY.xls: Same as **MAS_B.ASC.xls**, with available geolocation data (both original and transformed UTM-coordinates) merged to the data set. The corresponding Shape file is *mas_b.shp.*

MAS_C.ASC.xls: Soil samples from Wegener Halvø 1979–80, no coordinates. Only analyses for Cu, Pb, Zn.

NEW_A.ASC_xls : Rock samples from 1981–83. No coordinates, all analyses.

NEW_A.ASC_&_old_new_XY.xls: Same as **NEW_A.ASC.xls**, with available geolocation data (both original and transformed UTM-coordinates) merged to the data set. The corresponding Shape file is *new_a.shp.*

NEW_B.ASC.xls: Heavy mineral concentrates + stream-sediment and soil samples from 1981–83. No coordinates, all analyses.

NEW_B.ASC_&_old_new_XY.xls: Same as **NEW_B.ASC.xls**, with available geolocation data (both original and transformed UTM-coordinates) merged to the data set. The corresponding Shape file is *new_b.shp.*

NM4_A.ASC.xls: Rock samples from 1967–83 with coordinates and selected analyses.

NM4_A.ASC_&_old_new_XY.xls: Same as **NM4_A.ASC.xls**, with available key code and geolocation data (both original and transformed UTM-coordinates) merged to the data set. The corresponding Shape file is *nm4_a.shp.*

NM4_B.ASC.xls: Heavy mineral concentrates and stream-sediment and soil samples from 1968–83 with coordinates and all analyses.

NM4_B.ASC_&_old_new_XY.xls: Same as **NM4_B.ASC.xls**, with available key code and geolocation data (both original and transformed UTM-coordinates) merged to the data set. The corresponding Shape file is *nm4_b.shp.*

ROCK.ASC.xls: Rock samples from 1967-83 with coordinates and selected analyses.

DRAIN.ASC.xls: Heavy mineral concentrates and stream-sediment and soil samples from 1968–79 with coordinates and analyses.

DRAIN.ASC_old_new_XY.xls: Same as DRAIN.ASC.xls, with available geolocation data (both original and transformed UTM-coordinates) merged to the dataset. The corresponding Shape file is *drainage.shp.*

Folder no. 3 (Final_master_NM_Excel_files)

The files **NM4_A.ASC.xls** and **NM4_B.ASC.xls** seem to represent plot-files where the analytical data have been homogenised, i.e. the most reliable analytical values have been chosen for illustration purposes. They have been split into three files with key code and geolocation data, and are presented in the folder as:

ROCK_SAMPLE_MASTER.xls. Rock samples from 1967–83 with selected analyses. The corresponding Shape file is *rock_sample_master.shp*

HEAVY_MINERAL_CONCENTRATE_MASTER.xls. Heavy mineral concentrates from 1968–83 with all analyses. The corresponding Shape file is *heavy_minerale_concentrate_master.shp.*

STREAM_SEDIMENT_&_SOIL_MASTER.xls. Stream-sediment and soil samples from 1968–83 with all analyses. The corresponding Shape file is *stream_sediment_&_soil-_master.shp.*

Folder no. 4 (Original_transformed_NM_SHAPE_files)

In order to make the data accessible to commercial GIS-systems, the geolocated Nordmine data sets have been converted to Shape files. They are in the UTM projection, Zone 26, Datum WGS84. The Shape files contain both the original (Xutm, Yutm) and transformed (X_UTM_T, Y_UTM_T) UTM coordinates.

Shape files and the corresponding original data sets:

mas_a.shp	*(MAS_A.ASC_&_old_new_XY.xls)*
mas_b.shp	*(MAS_B.ASC_&_old_new_XY.xls)*
nm4_a.shp	*(NM4_A.ASC_&_old_new_XY.xls)*
nm4_b.shp	*(NM4_B.ASC_&_old_new_XY.xls)*
nm4_c.shp	*(NM4_B.ASC_&_old_new_XY.xls)*
new_a.shp	*(NEW_A.ASC_&_old_new_XY.xls)*
new_b.shp	*(NEW_B.ASC_&_old_new_XY.xls)*
drainage.shp	*(DRAIN.ASC_OLD_NEW_XY.xls)*

Folder no. 5 (Final_master_NM_SHAPE_files)

This folder contains the Shape files with the most reliable data sets:

rock_sample_master.shp. Rock samples from 1967–83 with selected analyses. The corresponding Excel file is *ROCK_SAMPLE_MASTER.xls.*

heavy_minerale_concentrate_master.shp. Heavy mineral concentrates from 1968–83 with all analyses. The corresponding Excel file is *HEAVY_MINERAL_CONCENTRATE-_MASTER.xls.*

stream_sediment_&_soil_master.shp. Stream-sediment and soil samples from 1968–83 with all analyses. The corresponding Excel file is *STREAM_SEDIMENT_AND_SOIL-_MASTER.xls.*

Folder no. 6 (NM_PDF_sample_maps)

The folder contains all samples ín three map files, cf. Section 6:

Rock_sample_map.pdf. using *rock_sample_master.shp.*

Heavy_mineral_concentrate_map.pdf. using *heavy_minerale_concentrate_master.shp.*

Sediment_sample_map.pdf. using *stream_sediment_&_soil_master.shp.*

4.2 Comments to attributes

The geological and geographical database attributes are described in the enclosed NM Coding Manual. The geochemical attributes are explained in the **KEYCODE.xls** file. Some comments are given below.

Type. Sample types as explained in List 1a (rock samples) and List 1b (sediment samples) in the NM Coding Manual. The prefix G for rock samples origins from the German “Gestein-

sprobe” and the prefix W for panned heavy mineral concentrate or in short pan sample comes from the German “Washprobe”.

In the laboratory, the samples were treated in the following way. For rock samples, a fragment of the sample was send to a commercial laboratory for crushing, milling and chemical analysis. The sediment samples were screened at 80 mesh (*c.* 0.1 mm) and a split of the fine fraction sent for analysis. The handling of the heavy mineral concentrates is illustrated in Figure 2. Note that the split for analysis was collected before magnetic separation of the sample. After splitting into magnetic, faintly magnetic and nonmagnetic fractions with a hand magnet, many 1968–74 samples were separated according to their magnetic susceptibility on a Frantz separator into mineral fractions.

Element symbols. These indicate analytical values. Laboratory, analytical methods, detection limits, etc. are listed in the **KEYCODE.xls** file. Many samples have been analysed, most frequently by semi-quantitative multi-element emission spectrography. Other methods applied include atomic absorption spectrography for base metals, X-ray fluorescence spectroscopy for tungsten, antimony, arsenic, barium and rare-earth elements, neutron activation for uranium, thorium, gold, tungsten and antimony, and fire-assay for gold and silver.

Sch_grs. The number of scheelite grains per 5 l sediment in the heavy mineral concentrates, counted under UV light in the laboratory.

5. Geolocation of sample sites

In the field, sample localities were plotted on aerial photos and later transferred to topographical maps, typically at scales 1:100,000 or 1:250,000. In Copenhagen, the localities were digitised using a digitizing table and converted to the UTM map projection (Zone 26, Datum NAD83??).

The topographic maps used with the original Nordmine Database were compiled by the Geodætisk Institute, Copenhagen. For the region north of 72ºN latitude compilation was in the period 1931–34, south of 72ºN it was mainly in 1950. A digital coastline based on these maps is included in the original Nordmine data (**COAST.UTM**). A new digital topographic map at 1:250,000 of North and Northeast Greenland has been produced by GEUS (Jepsen *et al.* 2003). When the two maps are compared, X-Y-deviations vary from less than 100 m to more than 1 km. Deviations in the southern part of the region are in most cases systematic but the geolocation accuracy becomes particularly poor north of 72ºN latitude where the overall geometry of the topographic features are in places very different from that on the modern maps.

Based on the comparison between the original coastline and the modern topographic map base, a transformation matrix of map data points was constructed and the original sample location coordinates were transformed using GEUS' in house software. The geolocated data sets contain both the original (Xutm and Yutm) and transformed (X_UTM_T and Y_UTM_T) coordinates.

The transformed UTM-coordinates must only be regarded as a first approximation for the apparent locations when the data are spatially visualised on the modern topographic map base. This is a best estimate but still imperfect.

6. Map presentation

The sample locations for rock samples, heavy mineral concentrates and stream-sediment and soil samples are shown on the three maps in Folder no. 6 (**NM_PDF_sample_maps)**. The maps contain modern topographic background data (coast, ice, alluvium, lakes, rivers, topographic contours) and the sample locations with partially posted sample ID information ("Number"). The map plots were produced at scale 1:250,000.

7. References

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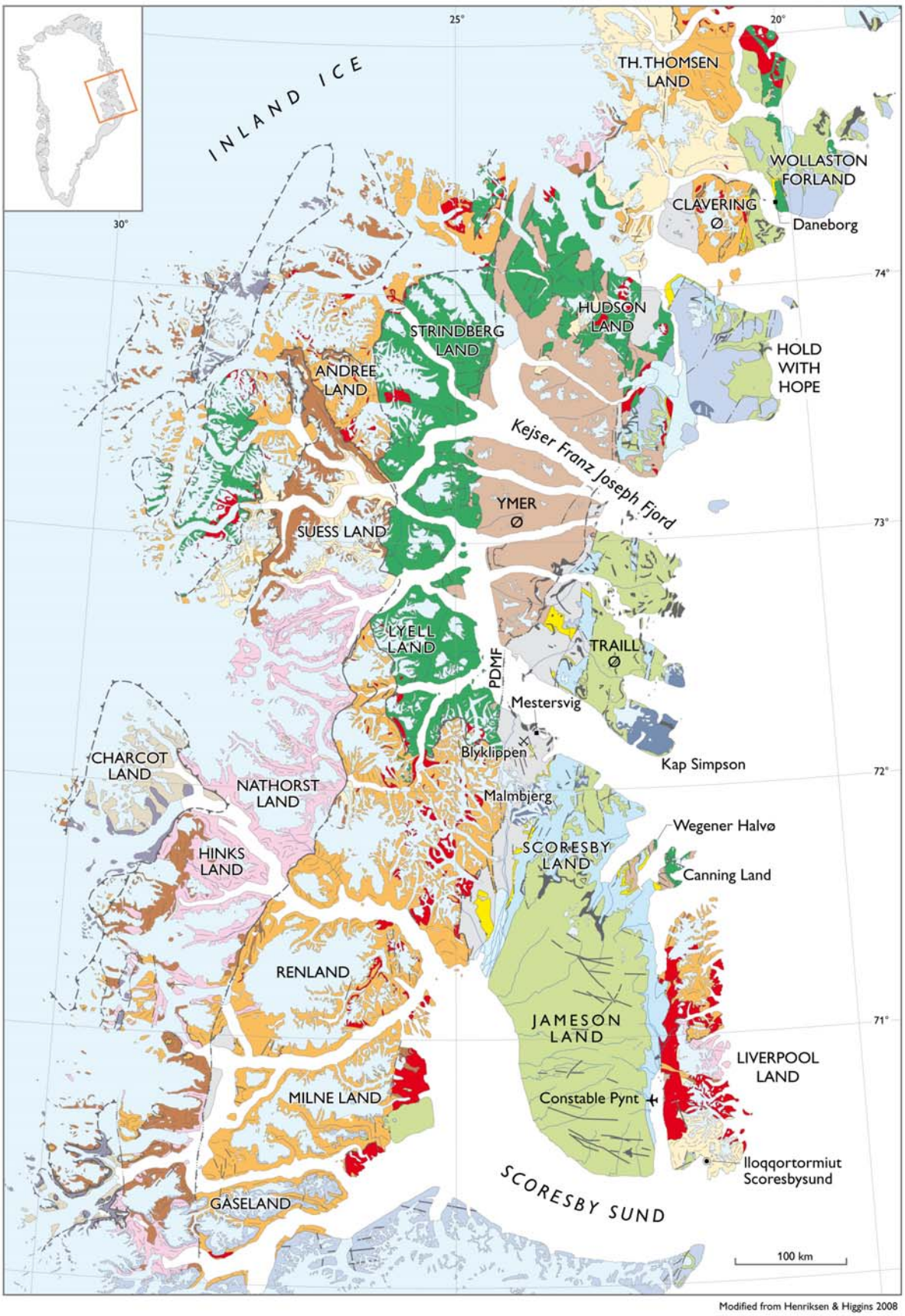

Figure 1. *Geological map of central East Greenland. Simplified from Henriksen and Higgins (2003).*

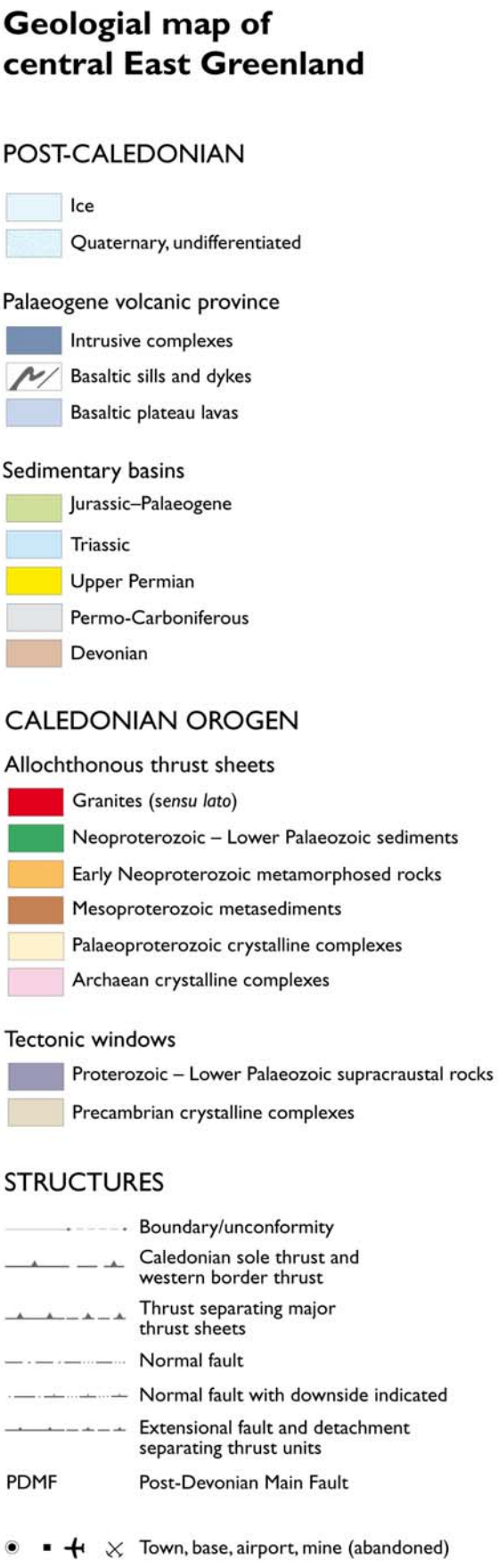

Figure 1. *Legend to geological map of central East Greenland.*

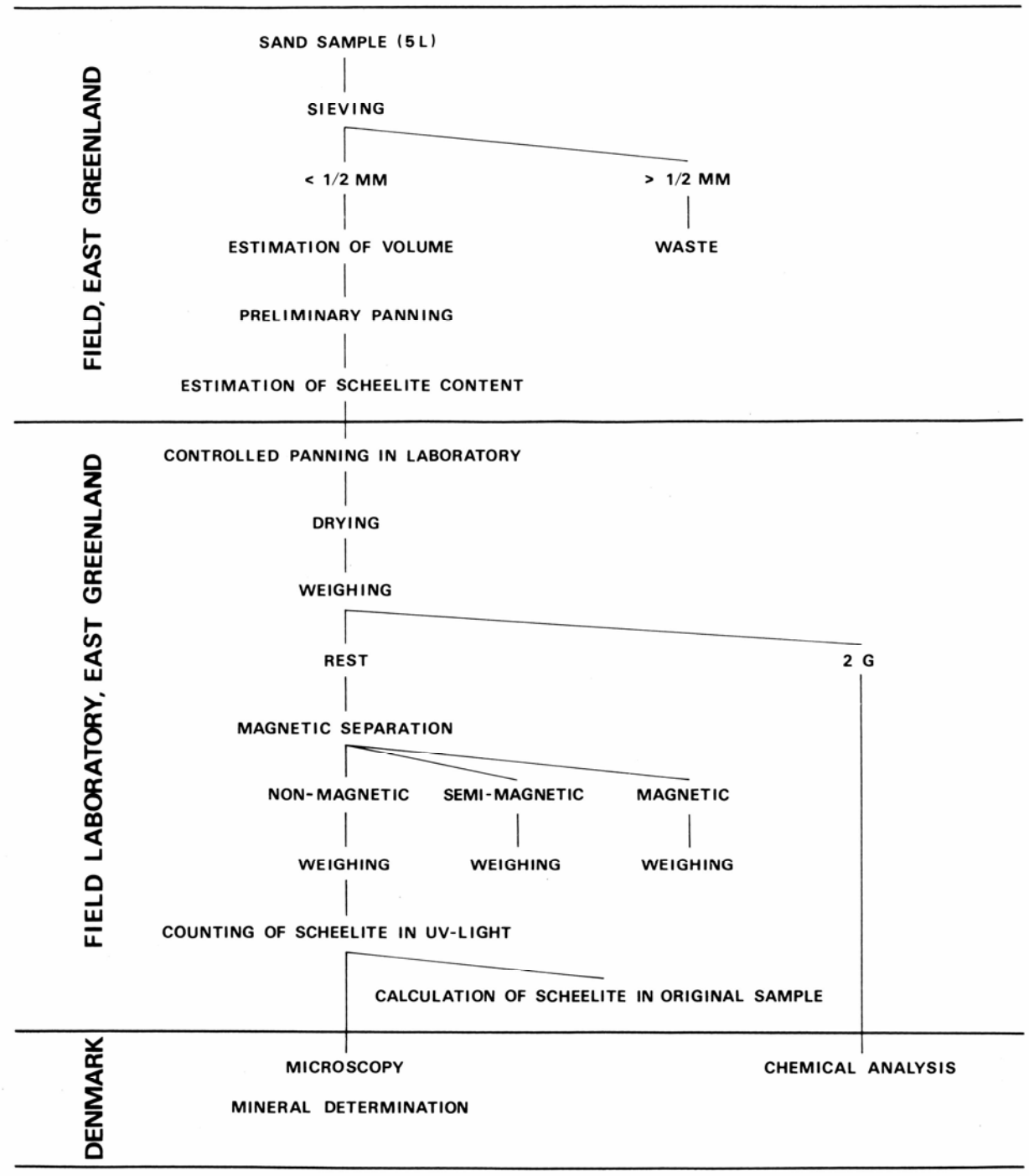

Figure 2. *Flow sheet for treatment of heavy mineral concentrates. From Hallenstein et al. (1981).*